Application for Letters Patent of

the UNITED STATES OF AMERICA by –

Richard H. Breinlinger
51 Wash Pond Road
Hampstead, NH 03841

Being a citizen of –

THE UNITED STATES OF AMERICA

For:

LOW COST MULTI-RANGE INPUT CIRCUIT FOR INDUSTRIAL ANALOG INPUT MODULES

PATENT
ATTY DOCKET NO SAA-83

TITLE OF THE INVENTION

LOW COST MULTI-RANGE INPUT CIRCUIT FOR INDUSTRIAL ANALOG INPUT MODULES

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to an input circuit for an analog input module used to process an analog input signal from a process control sensor to provide an input signal for a Programmable Logic Controller (PLC).

DISCUSSION OF THE BACKGROUND

Methods of controlling industrial processes have evolved from the beginning of industrial manufacture at the end of the nineteenth century up to the present day. To begin with, each step of a process had to be carried out by a human operator, with or without the aid of a machine. Later, systems for automatic control evolved, at first using purely mechanical means, and later using electrical control systems. With the advent of digital logic, and then computers, analog electrical control systems have largely given way to digital systems. Modern process control systems are typically controlled by a programmable logic controller (PLC). A PLC is essentially a computer containing a Central Processing Unit

(CPU) and memory. A PLC may be programmed typically from a terminal or from a general purpose computer. A PLC also has inputs provided for signals derived from sensors and outputs provided to control actuators. The sensors may measure process control variables such as pressure, temperature, flow rates, pH, oxygen content or any number of other variables from which proper operation of a process may depend. The actuators may, for example, control valves, solenoids or the like. Process control systems employing a PLC may be used to control any type of process in automotive plants, printing plants, breweries, or any other type of industry, and lower cost systems may be employed for home automation. Although the PLC is a digital device, the sensors and actuators employed in the process control system are often analog devices. For example, a pressure or temperature sensor may produce a voltage or current which varies continuously, i.e., in an analog fashion, dependent upon the quantity measured. Similarly, an actuator may, for example, control the position of a valve to regulate a flow dependent upon a value of an analog voltage. Analog input and output modules, collectively input/output (I/O) modules, are normally employed to convert the voltages and currents received from the sensors into digital values that can be processed by the PLC, and to convert the digital output values from the PLC into voltages or currents that can be used to control actuators.

An analog input module for a PLC may include an input circuit to convert an input analog voltage or current range to a voltage range suitable for an analog to digital converter, followed by an analog to digital converter, an optical isolator for safety reasons, and then a microcontroller. The microcontroller or any other suitable device provides an input to the

PLC. It will be understood by those skilled in the art that an analog input module may be used with a controller other than a PLC, such as a vision controller, an instrument controller, a data acquisition system, motion controller, or any computer. Examples of analog input modules are the Quantum, Kampai and 984 modules produced by Schneider Automation.

A difficulty arises in that several different voltage and/or current ranges may be provided by the different types of analog input sensors. One solution to this problem is to provide different types of analog input modules, each having a different voltage or current input range. A disadvantage with that approach, however, is that a number of different types of modules need to be provided and each one can only be used with certain types of sensors, so that the sensor has to be matched up with the analog input module having the same voltage or current range.

Another solution to this problem is to provide a multi-range analog input module. Such a module has up until now needed a switching mechanism to switch between different input circuits, depending on the voltage or current range to be input to the module. This is further complicated by the fact that it is desirable to control such switching remotely, i.e., from the PLC. The input modules are normally located close to the sensors, which may not be close to the PLC, and which in fact may be in hazardous or otherwise inaccessible locations. This is particularly but not exclusively true in the control of chemical processes, where toxic and/or explosive materials are processed. Consequently, it is desirable for such switching arrangements to be controlled electronically rather than mechanically, which greatly increases the component count in the input circuits and their attendant costs.

SUMMARY OF THE INVENTION

The present invention provides a novel input circuit. According to one embodiment, the input circuit forms part of an analog input module for a programmable logic controller or other control device. The analog input module includes an analog-to-digital converter and an input circuit with an output terminal connected to the input of the analog-to-digital converter, a voltage input terminal, a current input terminal, and a common terminal. The input circuit is configured to accept a voltage input between the voltage input terminal and the common terminal, to accept a current input between the current input terminal and the common terminal, and to provide an output voltage at the output terminal dependent upon either the voltage input or the current input, without switching between them.

A preferred embodiment of an analog input module according to the invention will be further described with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

[0011] Figure 1 is a diagram of a simple process control system;

[0012] Figure 2 is a diagram of a more complex process control system; and

[0013] Figure 3 is a schematic diagram of an analog input module according to one embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, Figure 1 is a drawing of a simple process control system. In this system input signals 105 from input sensors are processed by input modules 110 to provide digital signals to programmable logical controller 100. Programmable logic controller (PLC) 100 then provides digital outputs to output modules 120 which provide output signals 125 to actuators. PLC 100 may be programmed from a terminal or a general purpose computer 150.

[0015] Figure 2 shows a more complex process control system, still employing a PLC 100. In this example PLC 100 is mounted in a main rack 200 together with I/O modules 210, an external communications module 220, a distributed communications module 230, remote head 240 and power supplies. Each of the modules in main rack 200 are joined to a main back plane 290, which provides means for signals to flow between the various modules. As in the previous example, PLC 100 is connected to a terminal or general purpose computer 150 for programming. Additionally, PLC 100 may be connected via a local bus 270 to other computer systems in the same plant. PLC 100 is further connected via back plane 290 and external communications module 220 to an external bus 260 for external communications, such as a local area network (LAN), a wide area network (WAN) or the Internet. PLC 100 is further connected through back plane 290 to distributed communications module 230, which in turn is connected to distributed bus 280 to communicate with a plurality of distributed modules 250 in distributed racks 201. Only one distributed module 250 and one distributed

rack 201 is shown for the sake of clarity. Each distributed module 250 may be connected through a distributed back plane 291 to a plurality of I/O modules 211. Only one I/O module 211 is shown for the sake of clarity. PLC 100 is also connected through main back plane 290 to a remote head 240 for communication over remote bus 245 with one or more remote modules 255 in remote racks 202. Only one remote module 255 and one remote rack 202 is shown for the sake of clarity. Each remote module 255 may be connected through a remote back plane 292 to a plurality of I/O modules 212.

[0016] Figure 3 illustrates an analog input module according to an embodiment of the invention. In this embodiment an input circuit 310 is provided with a voltage input terminal 301, a current input terminal 302 and a common terminal 303, and is connected to a voltage supply rail 300 and outputs a signal 315 to an analog to digital (A-D) converter 320 which drives an optical isolator 330 and a micro-controller 340 to provide an output 350 to the PLC 100, as shown for example in the arrangements of Figure 1 or Figure 2, or in any other suitably configured process control system. Input circuit 310 comprises first, second and third resistors 304, 305 and 306 respectively, and first and second diodes, 311 and 312 respectively. Please note that, for the sake of clarity, not all connections to A-D converter 320, optical isolator 330 and micro-controller 340 are shown.

[0017] When the analog input module according to the embodiment is to be used with a sensor that provides a voltage output, the voltage from the sensor is applied between voltage input terminal 301 and common input terminal 303. In this voltage mode of operation first resistor 304 acts as a first leg of a voltage divider, while second and third resistors 305 and

306 in series with one another act as a second leg of the voltage divider. In this way, the voltage from a process sensor having a voltage output is reduced to the input voltage of the A-D converter 320.

[0018] When a process sensor providing a current output is used, the current loop is connected between current input terminal 302 and common terminal 303 of the input circuit 310. In this current mode of operation the resistor 305 connects shunt resister 306 to the A-D converter input 315.

[0019] First and second diodes 311 and 312 provide clamping of the voltage signal 315 fed from input circuit 310 to A-D converter 320. First diode 311 provides clamping for positive excursions of voltage, while second diode 312 provides clamping for negative excursions of voltage.

[0020] In a specific example of the circuit of the embodiment of Fig. 3, first resistor 304 may have a value of 15.3 kilohms (kΩ), second resistor 305 would have a corresponding value of 10 kΩ and third resistor 306 would have a corresponding value of 200 ohms (Ω). With a supply voltage of 4.096 volts (V) on the supply rail 300, the input circuit 310 converts a voltage input of 0 -10 V applied between voltage input terminal 301 and common terminal 303 into a voltage suitable for a common type of A-D converter, and alternatively a current input of 0-20 milliampères (mA) applied between current input terminal 302 and common terminal 303 can also be converted to the same input range suitable for the A-D converter. It will be appreciated by one skilled in the art that other values of resistance may be employed where other voltage and/or current ranges are to be employed, and where the operating

voltage of the A-D converter is different.

[0021] Although a number of different voltage and current ranges exist for analog process control sensors, the present inventor has found that an analog input module that can be used with one voltage range and one current range is much more useful than a module that can only be used with a single voltage or current range, and can be realized without switching means. This results in a multi-range analog input module that can be produced for virtually the same cost as a single range analog input module. Savings in cost from reducing the component count are further aided by economies of scale from producing only one type of analog input module. Such a dual range voltage/current input module is particularly of interest for use in low cost process control systems such as may be used in smaller industrial plants or in home automation.

[0022] In comparison with the background art, the circuit of Figure 3 has a much lower number of components, reducing both cost and complexity, and simplifying both manufacture, installation and configuration of the analog input module. This enables an analog input module employing the circuit of the preferred embodiment of the invention to be employed in lower cost systems, for example including smaller industrial plants and systems for home automation, where it is generally not economical to employ the same equipment that would be employed in, for example, a major chemical processing plant.

[0023] In an environment such as home automation, or in a small industrial plant, it is also highly advantageous that the analog input module of the invention can be set up with a minimum of configuration. The user has only to determine whether the sensor to be

connected provides a voltage output or a current output, and connect the sensor to the appropriate terminals of the analog input module. In such environments, a highly skilled technician may not be available to assist in installation, and, for example, the analog input module of the invention could be supplied together with input sensors that provide only a single standard output voltage or a single standard current output for each type of sensor to be used with the system.

[0024] Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.